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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/007,304	12/05/2001	Ki-Bum Kim	ASMMC.033AUS	2193

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EXAMINER
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RAO, SHRINIVAS H

ART UNIT	PAPER NUMBER
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2814

DATE MAILED: 08/13/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

**Office Action Summary**

Application No.

10/007,304

Applicant(s)

KIM ET AL.

Examiner

Steven H. Rao

Art Unit

2814

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

- 1) ☒ Responsive to communication(s) filed on 04 August 2003.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

- 4) ☒ Claim(s) 35-37,39-41 and 43-58 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☐ Claim(s) 35-37,39-41,43-58 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

**Application Papers**

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
- Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on \_\_\_\_\_ is: a) ☐ approved b) ☐ disapproved by the Examiner.
- If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

**Priority under 35 U.S.C. §§ 119 and 120**

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some \* c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
  2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- \* See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
- a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

**Attachment(s)**

- |   |   |
|---|---|
| 1) <input type="checkbox"/> Notice of References Cited (PTO-892)  | 4) <input type="checkbox"/> Interview Summary (PTO-413) Paper No(s). _____  |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)                                  | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO-1449) Paper No(s) <u>9 &amp; 10</u> . | 6) <input type="checkbox"/> Other: _____                                    |

***Response to Amendment***

Applicants' amendment filed on May 01, 2003 has been entered on June 04, 2003. Applicants' supplemental amendment filed on August 04, 2003 has been entered on August 05, 2003. Therefore claims 35 as amended by the supplemental amendment and claims 36,37, 39, 43-49,51-53 and 56-58 as previously filed are currently pending in the Application.

Claims 38 and 42 are cancelled by the Supplemental Amendment.

Claims 1-34 were previously withdrawn from consideration after election without traverse.

***Election/Restrictions***

This application contains claims 1-34 drawn to an invention nonelected with traverse in Paper No. 11. A complete reply to the final rejection must include cancellation of nonelected claims (37 CFR 1.144) See MPEP § 821.01.

***Information Disclosure Statement***

The information disclosure statements (IDS) submitted on January 31, 2003 and June 15, 2003 was filed after the mailing date of the 1st Office Action on January 30, 2003. The submission is in compliance with the provisions of 37 CFR 1.97. Accordingly, the information disclosure statement is being considered by the examiner.

*Claim Rejections - 35 USC § 102*

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

Claims 35-37,39-42 and 45 are rejected under 35 U.S.C. 102(e) as being anticipated by McTerr.( U.S. Patent No. 6,204,179, herein after McTerr)

With respect to claim 35, McTerr discloses a diffusion barrier for a copper interconnect comprising layer of metal nitride ( McTerr fig. 2 # 4, col. 17 line 64) covered by a layer of reactive metal different from a metal in the nitride layer (McTerr fig. 2 # 5, col. 18 lines 3-4), wherein the grain boundaries of the metal nitride layer are stuffed with a metal compound of the reactive metal. (McTerr col. 17 lines 45 to 55) wherein the reactive metal is selected from the group consisting of Al, Si, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mg, Y and La. ( McTerr col. 18 line 48-49) and the diffusion barrier directly underlies a copper layer of the copper interconnect. ( McTerr fig.2 # 4. col. 17 line 64) .

.With respect to claims 36 and 37, ( both claims not presently amended) wherein the metal nitride layer is selected from the group consisting of titanium nitride, tungsten nitride and tantalum nitride. ( Lai col. 17 liens 63-65)

With respect to claims 39-41,( amended to only change dependency from claim 38 to claim 35) wherein the reactive metal is selected from the group consisting of Al, Si, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mg, Y and La. ( Lai col. 18 line 48-49)

With respect to claim 45 ( not presently amended) wherein the different metal compound is a nitride of the reactive metal. ( McTERR col. 15 line 3)

With respect to claim 46 ( not presently amended) wherein the different metal compound is selected from the group consisting of aluminum nitride and silicon nitride ( McTERR col. 15 line 3 ).

With respect to claim 47 (not presently amended) wherein the metal nitride layer is about 5 to 10 nm thick. (McTERR col.18 line 3).

With respect to claim 48 (not presently amended) wherein the reactive metal layer is about 2 nm thick. (McTERR col. 18 line 8).

With respect to claim 49, (not presently amended) additionally comprising of a second layer of metal nitride over the layer of reactive metal. (McTERR fig. 9 and col. 15 lines 12 to 25).

With respect to claim 50, McTERR discloses a diffusion barrier for a copper in a interconnect comprising : a first metal layer of metal nitride (McTERR fig. 2 # 4, col. 17 line 64) , a layer of reactive metal layer directly contacting and over the first layer of metal nitride ( McTERR fig. 2 # 5, col. 18 lines 3-4) wherein the reactive metal is selected

Art Unit: 2814

from the group consisting of metals of group III B of the periodic table, metals of group IV B of the periodic table, metals of group V B of the periodic table and metals of group VI B of the periodic table ( see rejection of claim 35 above and this claim is rejected for the same reasons)and a second layer of metal nitride directly contacting and over the layer of reactive metal, wherein the grain boundaries of the first and second metal nitride layers are stuffed with a different metal compound. And the second layer of metal nitride underlies and contacts a copper layer of the copper inter connect (McTERR fig. 9 and col. 15 lines 12 to 25 and see rejection of claim 35 above and this claim is rejected for the same reasons).

With respect to claim 51, (not presently amended ) wherein the different metal compound is selected from the group consisting of an oxide of the reactive metal and a nitride of the reactive metal. (McTERR col. 15 line 3).

With respect to claim 52, (not presently amended ) wherein the layer of titanium nitride covered by a layer of aluminum, wherein the grain boundaries of titanium nitride layer are stuffed with aluminum oxide. (McTERR col. 17 lines 40 to 57).

With respect to claim 54, ( amended to only change "a" second occurrence to "the" ) wherein the diffusion barrier additionally comprising a second layer of titanium nitride between the aluminum layer and the copper filler. (McTERR fig. 9 and col. 15 lines 12 to 25).

With respect to claim 56, (not presently amended ) wherein the layer of metal nitride comprises titanium nitride. (McTERR col. 17 line 64).

With respect to claim 57, (not presently amended ) additionally comprising a second layer of metal nitride over the layer of silicon.( McTerr fig. 9 and col. 15 lines 12 to 25).

With respect to claim 58, (not presently amended ) wherein the second layer of metal nitride comprises of titanium nitride. (McTerr col. 15 lines 12 to 25).

***Claim Rejections - 35 USC § 103***

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

A. Claims 43, 44 and 55 are rejected under 35 U.S.C. 103(a) as being unpatentable over McTeer et al. (U.S. Patent No. 6,204,179 herein after McTeer as applied to claims above and further in view of Aoyama et al. (U.S. Patent No. 5,592,024, herein after Aoyama).

With respect to claim 43 (not presently amended ) wherein the different metal compound is an oxide of the reactive metal.

McTerr describes a reactive metal but does not specifically mention an oxide of the reactive metal.

However, Aoyama in column 19 lines 39-57 describes the use of silicon dioxide as an upper interlayer insulating film in three/four wiring layer structures to form interlayer insulators at temperatures lower than the melting point of the already formed metal lines.

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention to include Aoyama's silicon dioxide as an upper interlayer insulating film in three/four wiring layer structures to form interlayer insulators at temperatures lower than the melting point of the already formed metal lines. (Aoyama col. 19 lines 39-57).

With respect to claim 44 wherein the different metal compound is selected from the group consisting of aluminum oxide and silicon oxide. (Aoyama col. 19 lines 39-57).

With respect to claim 55, wherein the layer of metal nitride directly contacting and covered by a layer of silicon, wherein the grain boundaries of the metal nitride layer are stuffed with silicon oxide and diffusion barrier directly underlies a copper layer of the copper interconnect. (Aoyama col. 19 lines 39-57 and see rejection of claim 35 above and this claim is rejected for the same reasons).

**B.** Claim 53 is rejected under 35 U.S.C. 103(a) as being unpatentable over McTarr (U.S. Patent No. 6,204,179 herein after McTarr as applied to claims above and further in view of Aoyama et al. (U.S. Patent No. 5,592,024, herein after Aoyama) and further in view of Dutta (U.S. Pre grant Publication No. 2002/ 64592, herein after Dutta).

With respect to claim 53, (not presently amended) wherein the layer of titanium oxide is deposited by atomic layer deposition (ALD).

McTarr and Aoyama describes several method of dry deposition like CVD PECVD, but do not specifically describe ALD.



However, Dutta in col. 3 lines 1-2 describes several dry methods including ALD to have more precise control during the deposition of thinner layers and form a thin layer of better quality than by other dry methods.

Therefore it would have been obvious to one of ordinary skill in the art at the time of the invention to include Dutta's Atomic layer deposition method instead of Lai and Aoyama's dry methods like CVD to have more precise control during the deposition of thinner layers and form a thin layer of better quality than by other dry methods.

#### *Response to Arguments*

Applicant's arguments filed on August 04, 2003 have been fully considered but they are not persuasive for the following reasons :

First all the presently recited limitations of pending claims are taught/ suggested by the applied references as shown above.

Secondly McTerr describes in col. 17 lines 62 to 66 describes several metal nitride layers including any metal nitride layer , and this includes other metal nitride than the metal in the reactive metal layer .

FIG. 2 shows a cross-section of an insulating layer 1 of a silicon substrate having an opening which is overlaid with a 50 copper diffusion barrier layer 4 which is then overlaid with aluminum wetting layer 5. The copper diffusion barrier layer 4 may be any metal nitride and includes tantalum nitride (TaN), titanium nitride (TiN), tungsten nitride (WN) and a titanium aluminum nitride ( $Ti_{1-x}Al_xN_2$ ) having the atomic 65 composition described above in the description of FIG. 1 being preferred. The copper diffusion barrier layer 4 is

Thirdly , McTerr teaches the barrier layer is overlain with an Aluminum wetting layer ( col. 18 line 3) that reacts to form an alloy with an overlying copper layer ( col. 18 lines 15-18) .

Art Unit: 2814

barrier layer 4. The aluminum wetting layer 5 is deposited using PVD or CVD techniques well known to one of ordinary skill in the art and is deposited to a thickness of approximately 50 Å to approximately 500 Å, with approximately 200 Å being preferred.

above in the description of FIG. 1. Upon filling with copper, annealing and reflow, the aluminum wetting layer 5 is consumed thereby forming a  $\text{Cu}_n\text{Al}$  alloy layer 6 wherein n is an integer from about 0.5 to about 4. The  $\text{Cu}_n\text{Al}$  alloy layer 6 has a lower melting point (i.e., 450° C.) than elemental copper (i.e., 1000° C.), thus making it easier for the copper to flow into the opening. Although depicted as a total consumption of the aluminum wetting layer 5, it is to be understood that total consumption of aluminum wetting layer 5 may not occur upon the deposition of copper 3, annealing and reflow steps, and that some aluminum which is not in the form of a  $\text{Cu}_n\text{Al}$  alloy may be present in the layer which is depicted as the  $\text{Cu}_n\text{Al}$  alloy layer 6.

Fourthly , McTERR teaches its metal nitrides has grain boundaries that are stuffed with a metal compound of the reactive metal because McTERR teaches similar process as described in application specification page 6 ( Para 0033) lines 8 to 13 etc. subtitled “ a method of stuffing” using the same materials for the same purposes and what is true for Applicants’ is also true for the McTERR reference i.e. McTERR’s metal nitrides has its grain boundaries that are stuffed with a metal compound of the reactive metal.

Applicants’ argument regarding inherency is not persuasive because Applicants’ specification states that the preferred embodiment ( indeed the only embodiment) states that the similar process with same materials for the same purpose Always produces the stuffing and this is also true for the McTERR reference.

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

Art Unit: 2814

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communication from the examiner should be directed to Steven H. Rao whose telephone number is (703) 306-5945. The examiner can normally be reached on Monday- Friday from approximately 7:00 a.m. to 5:30 p.m.

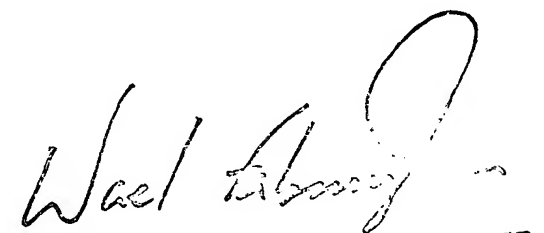
Any inquiry of a general nature or relating to the status of this application should be directed to the Group receptionist whose telephone number is (703) 308-0956. The Group facsimile number is (703) 308-7724.



Steven H. Rao

Patent Examiner

August 09, 2003.



SUPERVISORY PRIMARY EXAMINER  
TECHNOLOGY CENTER 2800